Specific Challenges in Visualization Research and Deployment

David S. Ebert
Purdue University
September 10, 2004

1. Effective Visual Representations For Real-World Problems

During the past twenty years most, visualization researchers have concentrated on developing new rendering techniques to display scientific data, producing a collection of potentially very useful methods. However, there has not been enough effort in viewing visualization as part of a larger process for conveying information, solving problems, making decisions, and enabling scientific discovery. We need the ability to:

- start from an understanding of the problem to be solved, the hypothesis to be tested, and question to be answered;
- determine the elements of the data that are necessary for this task;
- understand the data characteristics;
- determine effective visual representations of this data for this task; and then
- convey the information.

We need to integrate techniques for information extraction and abstraction with algorithms for visual presentation of information. Harnessing principles of human perception is also key to developing effective techniques for conveying this information, since we are creating images and motion to be interpreted by the human visual system.

We also need to develop techniques to work with the unstructured, irregular, multifield, massive datasets that scientists, doctors, and analysts encounter on a daily basis. First of all, we need improved algorithms that work across a multitude of problem scales. Secondly, we need effective techniques to take numerous data quantities (e.g., multiple fields of data) and present them understandably to the user. One effective strategy for this problem is to utilize techniques developed in other disciplines to address similar tasks. Therefore, we should incorporate concise, effective methods for presenting information that designers and illustrators have developed throughout history.

We also need the ability to test and evaluate these algorithms on representative, real-world problems. Most fields have gold standards used for evaluation and benchmarking. We need to develop a collection of practical-sized test datasets with articulated characteristics and known solution values for evaluation and development of visualization software.

2. Accuracy, Reliability, and Reproducibility

For actual deployment and use of visualization, it is critical that we develop accurate, reliable, software with consistent, reproducible results. Scientists should be able to get the correct information from their datasets, know when they aren't getting the correct information, and know how to adjust the software parameters from one dataset to the next to produce a reliable answer. We also need to present information on the accuracy and errors in the computations used to produce the visual representation.

3. Usability and Interactivity

Another key feature of the acceptance and use of visualization is the usability of the system. Interactivity is an important consideration to allow visualization to be used effectively to solve problems. However, it is only one component. The usability and understandability of the system and its controls are even more critical. We need to create systems that are easily used by experts and novices alike. It is essential that the user be presented with controls that are easy to understand and relevant to their application domain. We also need to be able to explain how these controls effect the visual presentation of the underlying data to make the user confident that the science is still valid. For example, the shininess or amount of 2^{nd} directional derivative gradient enhancement should not influence a medical diagnosis.